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A REMOTE SENSING APPLICATIONS UPDATE

**RESULTS OF INTERVIEWS WITH EARTH OBSERVATIONS
COMMERCIALIZATION PROGRAM (EOCAP) PARTICIPANTS**

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PREFACE

This study has been undertaken by the Center for Space and Geosciences Policy at the University of Colorado, Boulder, as part of our research in geosciences policy supported by NASA Grant NAGW-1415. The Center proposed to build on the investment NASA has made in the remote sensing applications community by reporting on the needs of applications users. The original proposal focused on user involvement in an Applications Information System design, one of the key recommendations of the 1987 NASA report, "Linking Remote-Sensing Technology and Global Needs: a Strategic Vision. A Report to NASA by the Applications Working Group", L.R. Greenwood, Chair. The proposed plan was modified to look at user needs more generally, i.e., without specific reference to a dedicated applications information system.

Applications investigators and users in the Earth Observations Commercialization Applications Program (EOCAP) were chosen as the study population. EOCAP began in 1987 as a NASA program jointly administered by the Earth Science and Applications Division of the Office of Space Science and Applications, and the Science and Technology Laboratory of the Office of Commercial Programs. Twenty-one applications projects were selected for EOCAP participation in response to the 1987 NASA Research Announcement (NRA). The projects are now entering the final year of a three-year program. The Center was interested in the EOCAP population because the projects included a variety of organizational participants and many different kinds of applications.

The Center's study was neither conceived nor carried out as an evaluation of EOCAP or its participants, but rather as an inquiry into the current status and needs of the applications user community, in light of the changes in remote sensing capabilities and applications that will likely follow from implementation of NASA's Earth Observing System (EOS).

This work was carried out by Sally McVey under the direction of Radford Byerly, Jr.

Summary of Results

The principal findings of the study of EOCAP users are as follows:

1. Essentially all EOCAP projects are working on problems associated with managing large-scale natural-resource holdings.
2. Resource management information needs are being driven by a pervasive renewed interest in the environment and the need for more detailed information.
3. Synoptic coverage offers unique possibilities for cost-effective resource management operations.
4. Recent advances in geographic information system (GIS) technology and digital data and image processing technology are putting remote sensing tools within reach of more resource managers. Training operating personnel to use technology developed in the project is among the highest priorities for EOCAP users.
5. Most EOCAP end-users want to continue using Landsat data, but data costs, delivery problems, and the uncertainty over Landsat's future constrain the development of applications.
6. Essentially all participants find collaboration with NASA Centers, universities, other agencies, and commercial firms to be valuable. Most end-users would participate in a project like EOCAP again, in spite of start-up problems.
7. End-users will gauge EOCAP success by their ability to use technology developed during the project in their own operations. In this regard data continuity is seen as a necessary prerequisite for continuing end-user interest in remote sensing.
8. Most EOCAP investigators and many end-users are aware of the Earth Observing System (EOS) program. However, few now see the program as benefiting applications. Many investigators and some agency end-users are interested in working on global change problems. Global change and responses to it will further impact their operations and responsibilities in much the same way that environmental concerns have already impacted them.

Our conclusions are as follows:

o General conclusion:

Earth remote sensing is a uniquely valuable tool for large-scale resource management, a task whose importance will likely increase world-wide through the foreseeable future.

NASA research and engineering have virtually created the existing U.S. system, and will continue to push the frontiers, primarily through the EOS instruments, research, and data and information system. In our view, the near-term health of remote sensing applications also deserves attention; it seems important not to abandon the system or its clients.

This study suggests that like its Landsat predecessor a successful Earth Observing System program (as part of the U.S. Global Change Research Program), is likely to reinforce pressure to "manage" natural resources, and consequently, to create more pressure for EOCAP-type applications. The current applications programs, though small, are valuable because of their technical and commercial results, and also because they support a community whose contributions will increase along with our ability to observe the earth from space.

o Specific conclusions:

1. Resource Management users in industry and all levels of government constitute a potential market for remote sensing data and technology. Maintaining remote sensing applications programs will provide another dimension of use for EOS data, and accordingly additional support for EOS.
2. Little has changed in amelioration of the systemic problems that continue to undermine U.S. earth remote sensing operations; the overarching issues seem intractable, but progress is being made in small-scale applications projects as exemplified by the EOCAP program, which is making an important contribution in this area.
3. In proper accord with its charter, NASA's interest in earth remote sensing is focused on earth science. The agency's role in remote sensing applications is limited but still important. EOS data will ultimately offer enormous opportunity for operational management of earth resources, but in the meantime, EOCAP results will likely advance the state of the practice, and the program is building public-private and inter-agency collaborations that have great potential for further advances in the future.
4. The issues of Landsat commercialization and applications interact to complicate the situation with respect to the use of EOS data outside the global change research program. On the one hand the primary purpose of EOS might be undercut politically if a large number of applications users felt excluded from EOS data. On the other hand, the reason for EOS is scientific, and science users and uses must be given top priority: Given limited and strained resources, if EOS is operated in part to serve applications users, its primary users and purpose will be compromised. It is possible that the Land Remote Sensing Commercialization Act of 1984 might offer a solution to this potential problem. That is, it is possible that "commercialization" could provide the needed separation between the scientific purposes of EOS and the potentially broader, practical usefulness of its data. An approach worth studying would be to offer one or (better) two "ports" into EOS/DIS to

commercial data providers. The exact definition of a "port" would have to be negotiated, but basically NASA through the commercial entities would offer EOS data at cost plus a fee or royalty. Having two competing offerors should keep data prices to users down to reasonable levels. A competitive selection would award the ports to the two bidders proposing the best deal to the government and to applications users. It would be clear that in doing so NASA's purpose would be to make EOS data available cheaply and fairly to existing commercial and other applications users; not to promote or generate an applications community. Such an approach could benefit the EOS program: EOS could concentrate on Earth systems science and leave applications to other relevant organizations.

I. THE EARTH OBSERVATIONS COMMERCIALIZATION APPLICATIONS PROGRAM (EOCAP) STUDY

Context and Methods

The Center for Space and Goesciences Policy has interviewed 45 EOCAP participants: twenty of twenty-one Principal Investigators (PIs) and twenty-four of sixty-seven Co-Investigators (CO-Is, end-users, or users) (See Appendix A). These interviews add an anecdotal update to a series of previous studies of the status of the U.S. remote sensing applications endeavor. Examples of such studies include:

- o United States Civilian Space Programs: Volume II. Applications Satellites. Prepared for the Subcommittee on Space Science and Applications of the Committee on Science and Technology, U.S. House of Representatives by the Science Policy Research Division, Congressional Research Service, Library of Congress. May, 1983.
- o Remote Sensing of the Earth from Space: A Program in Crisis. Space Applications Board, National Research Council. 1985.
- o Space-Based Remote Sensing of the Earth from Space: A Report to the Congress. NOAA/NASA. September, 1987.
- o Keystone Landsat Policy Dialogue. The Keystone Center. October, 1989.
- o James V. Taranik. "Landsat, Privatization, Commercialization and the Public Good". Space Commerce, Vol.1, pp.67-80. 1990.

These reports describe the context in which U.S. Remote sensing applications work is taking place. Key remote sensing issues discussed in these and other publications include privatization of Landsat and continuity of operations and data, the market for applications, maintenance of U.S. pre-eminence and competitive position in earth observations, user needs, and evolution of remote sensing instrumentation and data processing techniques. Most of these issues remain alive and unresolved.

The present study was motivated by an interest in soliciting input from the applications user community. Among other recommendations, the report of an applications working group chaired by L. R. Greenwood in 1987 suggested that:

"NASA should develop mechanisms to involve users heavily in its R&D program and state this intention publicly; users should be involved at all stages from inception through implementation." [NASA, 1987, p. 13].

The 1987 EOCAP NRA reflected this recommendation in its program goal and objectives:

"Initially emphasize a near-term remote sensing applications program, while gaining feedback from the user community as inputs into future NASA program planning." [NASA, NRA-87-OSSA-6, p. 1]

In our telephone interviews with EOCAP participants, separate sets of questions were asked of PI and User groups and ancillary lines of inquiry were followed in cases where interesting points arose. The questions are listed in Appendix B.

The EOCAP program was chosen as our sample because of the variety of institutions and participants involved, and because the common proposal requirements and selection processes were assumed to facilitate comparability. Although we have not determined whether the EOCAP sample is representative of the entire applications community, the possibility that EOCAP information can stand alone as an indicator of current applications issues is suggested by the involvement of eleven state universities, eight state and local agencies, nineteen for-profit and two private non-profit organizations, and twelve agencies or centers in four federal departments. These organizations are listed in Appendix C. Consideration of EOCAP applications issues may inform some aspects of the next generation of U.S. earth observations: NASA's Earth Observing System (EOS). EOS will include two series of polar orbiting platforms with instruments that will provide coordinated, simultaneous measurements of earth system interactions. Launch of the first platform is currently scheduled for 1998. Among the proposed instruments of great interest to applications users are the High Resolution Imaging Spectrometer (HIRIS), the Moderate Resolution Imaging Spectrometer (MODIS), and the Synthetic Aperture Radar (SAR). Other components of EOS include an advanced data and information system and interdisciplinary investigations of global change. (NASA, September 1988, p. 115-118. NASA, February, 1990, p. 1. Earthquest, 1990, p. 6.).

Characterizing the EOCAP sample

- Principal Investigators

Fourteen of the twenty EOCAP principal investigators interviewed are affiliated with publicly-funded institutions, either government agencies or universities (Table 1). Thirteen of the fourteen public sector PIs are involved with resource management projects; the other is working in climate analysis.

The remaining six PIs come from the private sector, and represent industrial firms, value-added companies, systems developers, and non-profit organizations. Three PIs are

working on resource management projects, and the others are involved in resource exploration, and logistical support for exploration and commercial fishing operations.

- Users

Forty five of sixty-seven EOCAP users are affiliated with government agencies or public universities, and 22 with commercial organizations. Of these commercial participants, six are affiliated with major corporations, eleven with value-added firms*, three with computer systems development companies, and two with private non-profit companies.

- Projects

Most EOCAP projects are dealing directly with such resource management tasks as forest inventory, natural hazards assessment, or crop yield prediction, however some of the commercial projects are concerned with logistical support for resource exploration, extraction or harvest. For example, an EOCAP project with oil and gas company participants is looking at sea-ice forecasting for off-shore arctic drilling operations, and a commercial fisheries project is using remote sensing to track fish movement in the Gulf of Mexico.

If logistical support for natural resource operations is included in the definition of "resource management", nineteen of the twenty projects in the EOCAP study are resource management projects.

*i.e., firms that process and analyze remote-sensing data, thereby adding value to it.

II. FINDINGS

Finding 1:

o Essentially all of the EOCAP projects are solving problems associated with managing large-scale natural resource holdings.

"The potential is there. This will be a useful product in 10 years. But in 10 years, we'll only have archival information to work with because there won't be any wetlands to look at in real time. We're being asked to manage a diminishing resource and the conclusion is right there in front of us."

Dr. Doug Barnum, U.S. Fish and Wildlife Service, DOI

EOCAP users need remote sensing tools to help them survey, monitor, or otherwise manage large areas ranging in size from an Indiana county to the National Park Service holdings in Alaska and the lower forty-eight states. The budgets of resource management agencies at all levels of government are under pressure. As one participant noted, "Demands on the Department of Natural Resources for good, accurate, and timely information are increasing and the budgets for traditional methods of producing such information are decreasing with time, so that's why they're interested in satellite data."

The project "product" most commonly desired by both private and public sector resource managers is information to feed their management decision processes. Barnum pointed out that managers want to fine-tune their skills, "We've got intuition, but no real information. We deal on the microscale...everyone knows his own area, but we need to know how to manage water in California in toto...I can't overstate the importance that wetland agencies will attribute to this technology."

Finding 2:

o Resource management information needs are being driven by a pervasive renewed interest in the environment and the need for more detailed information.

According to EOCAP users, the combination of legislation and renewed public and political interest in the environment is magnifying needs for resource management information. The spotted owl controversy recently led to a Forest Service contract for a remote sensing survey of old growth forest in California, and the Yellowstone fire in the

summer of 1988 influenced National Park Service interest in participating in an EOCAP satellite forest-fire alarm project.

Traditionally, when dealing with the environment the timber industry has taken the approach "tell us what to do". In spite of this, California's largest private timber landowner wants to show that it knows more than anybody else about the lands that it manages, according to Ed Murphy, Inventory Forester at Sierra Pacific Industries. "This puts us in a better position in managing the multitude of resources that originate in our forests." Sierra Pacific must submit the functional equivalent of an Environmental Impact Statement in the state's timber harvest planning process. Stewardship of the owners combined with state regulations are moving this company in the direction of more comprehensive management of all its resources.

Public agency managers have also been affected by public interest in the environment for some time. A paper co-authored by an EOCAP participant in the Oregon Department of Fish and Wildlife noted that today's "managed forest" is the product of 1) environmental legislation dating from the 1970's, and 2) government budget decisions that affect implementation of those laws (Thomas et al.). The current resurgence in environmental awareness is pushing resource managers in new directions. One user commented that "the Forest Service hasn't thought at all about the cumulative impact - the global impact of our actions...the impact of large-scale deforestation, but it may be forced on us. Some of the more resource-oriented people think about it, but the change won't come from inside. For example, concern for the spotted owl, which inhabits old growth forests, is an outside force that is now affecting us." Another Forest Service representative simply noted that "the public is turned off by the way we clear-cut."

Finding 3:

o Synoptic coverage offers unique possibilities for cost-effective resource management operations.

The combination of budget constraints and increasing emphasis on resource management operations in agencies and industry is promising for remote sensing applications because synoptic coverage offers large amounts of information at low cost. EOCAP users said that with traditional technology they cannot afford to monitor forests or update land-use files for tax assessment or growth prediction as often as regulations require. These users are interested in the capability of remote sensing data to increase their efficiency at costs which are the same or lower than those of traditional methods. The size of the areas managed by EOCAP participants precludes recourse to either ground surveys or aerial photography as alternate sources of data for inventory and change detection. Typically, users want more detailed information on shorter update cycles.

For example, nearly half of the state of Minnesota is forested, with much of the forested area in the public domain, and at the Minnesota Department of Natural Resources, the Supervisor of Resource Assessment and Analysis says "I need to know how many cords of birch I've got." Echoing the comments of other users, Mr. Michael Carroll describes his perspective on remote sensing benefits: "We are looking for a cost-effective method to reduce the dependence on the expensive traditional aerial photo interpretational mapping methods...it has to be cost-effective or do something better than the way we're doing it now. We're very pragmatic about it."

Commercial users are also looking for ways to improve operating efficiency. At the largest commercial fishing interest in the U.S., the Project Engineer told us, "there is only so much you can do in traditional ways to cut costs -- if this technology works, it's well worth the costs."

A major oil and gas company representative pointed out that seismic information needed for exploration costs his company millions of dollars each year, "another success would be if we could reduce the cost of seismic information...with this technology, we wouldn't spend less money, but we would spend it more effectively". Another oil and gas company representative in an EOCAP sea-ice forecasting project said that drilling-support operations in the arctic cost \$200,000 to \$300,000 per day. "Efficient forecasting can save money by reducing downtime." An EOCAP user representing the United States' largest food service business says, "we're in a competitive business -- if we can stay a quarter-step ahead of our competition, this technology will be useful. Information from this project won't reduce the cost as much as it will increase efficiency. With remote sensing information, our planes can know better where the fish are likely to be, and then the ships can go directly to the field instead of going somewhere else first."

Finding 4:

o Recent advances in geographic information systems (GIS) and digital data and image processing technology are putting remote sensing tools within reach of resource managers. Training personnel to use technology developed in the project is among the highest priorities for EOCAP participants.

Several earth remote sensing reports issued during the 1980s linked demand for satellite data to improvements in data processing technology.

In 1987, a NOAA/NASA report noted that "Because of the very high potential utility of satellite data, especially multi-spectral imagery, and the very broad spectrum of possible users, a significant increase in demand can be expected as the necessary skills and equipment become more widespread. Many programs project that the use of satellite data will double or triple within a few years." [NOAA/NASA, 1987]

In light of such comments it is interesting to note that nearly all of the EOCAP projects are developing digital data processing or GIS technology; some projects are using commercial systems and others have systems developers on the project team. EOCAP projects in both public and private sectors expect to produce systems that staff members without remote sensing backgrounds can be trained to use.

A user in a state department of natural resources summed up his ideas on changes in the field of remote sensing, "thinking about applications must take into account the tremendous explosion in the data processing capability of the average resource manager...the days when the data was intelligible only to specialists are gone forever."

An EOCAP PI and vice-president of a large resources consulting firm adds, "When NASA developed those airborne sensors five years ago, no one had the foresight to see where we'd be now with GIS, storing and analyzing digital data -- how it would change engineering and forestry."

With the prospect of having synoptic data, GIS, and image processing systems tailored to their operations, EOCAP resource managers are defining their needs. As one user put it, "I want my staff to be able to make forest inventory calls from the desk." As is the case with other users, training staff to use project technology is among this manager's requirements for EOCAP. A remote sensing specialist with a regional government land-use agency explains: "The University brought us up to speed fast on satellite imagery, but we ultimately have to do it ourselves. Seeing applications [demonstrated] is different from doing it ourselves."

Project PIs share the concern about transferring the technology. One agency investigator describes his current training role, "I teach resource managers in the field about what's available in remote sensing data and techniques. I'm not in technology development at the moment - I'm an extension type, educating others."

The increasing capability of remote sensing data processing technology to improve management operations is perhaps the most positive development in applications in recent years.

Finding 5:

o Most EOCAP end-users want to continue using Landsat data, but data costs, delivery problems, and the uncertainty over Landsat's future constrain applications development.

About half of the EOCAP projects are using Landsat as their primary source of data. Two are using the Advanced Very High Resolution Radiometer (AVHRR) (one in conjunction with Landsat); the High Resolution Interferometer Sounder (HIRS) and a Geostationary Operational Environmental Satellite (GOES) each supply data for one other project. The remaining projects primarily use airborne instrument data: the Thermal Infrared Multispectral Scanner (TIMS), the Calibrated Airborne Multispectral Scanner (CAMS), the Airborne Ocean Color Imager (AOCI), and radar. One airborne radar user intends to switch to the European Earth Remote-Sensing Satellite (ERS-1) Synthetic Aperture Radar (SAR) data as soon as it becomes available. Relatively more commercial projects are using aircraft data than are public sector projects. Nearly all projects use ancillary data sets including SPOT (8 of 20 projects), digital elevation data, and aerial photography.

In discussing their data needs, the investigators using Landsat data frequently mentioned that Landsat was best suited for their application, in spite of the enhanced spatial and temporal resolution and better service offered by SPOT. Several noted the cost advantage of Landsat data relative to Spot and aerial photography. However, as one university PI noted, "The uncertainty about Landsat has hampered applications development at the state level and in other agencies. Potential users ask, 'If I invest in Landsat, will it be up there next year, or 5 years from now?' "

Most EOCAP participants had data delivery problems due to negotiation delays in the NASA-EOSAT data grant or due to aircraft scheduling constraints. Data cost was a potential problem for many users because their applications required frequent coverage and/or coverage of very large areas.

Finding 6:

Essentially all participants find collaboration with NASA Centers, universities, other agencies, and commercial firms to be valuable. Most end-users would participate in a project like EOCAP again in spite of start-up problems.

Because the first EOCAP program has one more year to run and because of start-up delays, it is too early to evaluate technical, operational, and commercial success, according to users on most projects. However, Users and PIs alike described project collaborations as an outstanding benefit of participation. This result is particularly important because one of the specific objectives of the EOCAP program is to "emphasize private sector, university, and government partnerships, which require joint initiative and resources for high technology ventures while sharing risk."

Users commended Stennis Space Center and Ames Research Center team members for their contributions, including technical expertise and help in working with the NASA

system, which was especially problematic for commercial users. One Forest Service participant commented that "this is an unusual project for the Forest Service -- it got support due to NASA's name."

Finding 7:

o End-users will gauge EOCAP success by their ability to use technology developed in the project operationally. In this regard, data continuity is seen as a necessary prerequisite for continuing end-user interest in remote sensing applications.

When asked how he would gauge the success of the EOCAP project, one state agency participant captured the sentiment expressed by most operational users, "When the technology is running in my shop!" A Department of the Interior user says "If our people have confidence in the project technology, they'll fund it down the line and use it. The measurement of confidence is whether people will use it in the dispatch or not dispatch decision [for firefighters]. But there are problems with allocations of resources...some people don't want to spend pick and shovel money on satellite systems."

Although users praised project commitments to training and the benefits of multi-institutional cooperation, many of them were concerned that NASA and university participants might not fully understand the realities of users' operational and business environments.

A user dealing with inter-jurisdictional resource management issues commented, "We are a real-life lab for this project. We want to know if what comes out will work in the real world. Our 1990 land-use inventory has to serve as a baseline for growth forecasts here and at the State level. This is a real schedule -- we're production oriented."

According to EOCAP participants, moving from technology development to operational capability requires collaboration, tools, training, and in some cases, creating specialized service providers.

One user noted that the Forest Service is a decentralized agency, and would most likely contract with value-added organizations for remote sensing application services. One of this participant's objectives is to create in-house remote sensing expertise in order to deal with specialized contractors. Participants in local government, regional offices of federal agencies, and industrial users also indicated that they would use the services of remote sensing value-added firms rather than develop and support in-house expertise. An industrial participant said,

"In the upside scenario, the question is, 'How can we commercialize this technology?'. Our industry says that you can't hold exploration for more than two years. What is the value of that head-start? Do we want to commercialize it ourselves, or go to someone else and have them develop the instrument...We've done this successfully in the past."

A question remains about where these users will go for remote-sensing services after EOCAP projects are completed if the market is not yet able to support service providers.

In a different approach, the National Park Service, the Oregon Department of Fish and Wildlife, and the Departments of Natural Resources in Minnesota and Florida have in-house remote sensing departments, and expect to further develop their internal capability.

Finding 8:

o Most EOCAP investigators and many end-users are aware of the Earth Observing System (EOS) program, but few now see the program as benefiting applications in the near-term. Most PIs and many users are interested in working on global change problems. Global change and responses to it will further impact their operations and responsibilities in much the same way that environmental concerns have already impacted them.

A prominent characteristic of the EOCAP population is that nearly all users had training in remote sensing applications: several are remote sensing specialists and many others had courses in remote sensing in graduate school; both agency and commercial users had learned about applications potential from previous experience with NASA. As a consequence of their interest in remote sensing generally, or their contact with NASA centers through the EOCAP projects, most of the participants had heard of NASA's Earth Observing System program.

Many participants in federal agencies are interested in global data sets and want to work on global change problems, often in conjunction with their agency's participation in the federal Global Change Research Program.

In this connection, several EOCAP PIs are participating in EOS investigations, and others hope to do so. Among the users, several know about EOS because of the activities of their colleagues, or their own participation in remote sensing activities at the national level. Many others were aware at the "ordinary citizen" level, having seen or heard about the Mission to Planet Earth in news accounts of global change.

In commenting on NASA's science mission, participants with remote sensing expertise were concerned that applications do not appear to be a priority use for EOS data. One participant commented:

"We need two things: continuity for historical and current data, and improved EOS data...we're interested in questions with global significance, but we want continuity. We want hyperspatial data to answer questions in forestry and ecology -- new sensors can answer some questions, but without continuity, we waste the work of the last twenty years. It is important not to have EOS just dumped on us, but to bring us along, for us to be part of the process during the next seven years, for us to be informed so we can make adjustments."

A representative from a value-added firm adds,

"I am interested in EOS, but the infrastructure for providing data to users has to be examined. Users aren't involved in distribution plans. Data can't just be archived for posterity -- there has to be a day-to-day data stream available for users in the real world, they need current data. EOS has to be different than past projects. People in applications have a different mindset than people in R&D, [applications people] need a different process to support them. Science projects have exclusive use of a new sensor and data for a few years. That worked for new sensors, but we're not using any new sensors [on EOS], we are using improved versions of old sensors: altimeters, scatterometers...what we'll really be doing is more data collection, so the framework for data distribution needs to be different."

III. CONCLUSIONS

Our conclusions are as follows:

o General conclusion:

Earth remote sensing is a uniquely valuable tool for large-scale resource management, a task whose importance will likely increase world-wide through the foreseeable future. NASA research and engineering have virtually created the existing U.S. system, and will continue to push the frontiers, primarily through the EOS instruments, research, and data and information system. In our view, the near-term health of remote sensing applications also deserves attention; it seems important not to abandon the system or its clients.

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3. In proper accord with its charter, NASA's interest in earth remote sensing is focused on earth science. The agency's role in remote sensing applications is limited but still important. EOS data will ultimately offer enormous opportunity for operational management of earth resources, but in the meantime, EOCAP results will likely advance the state of the practice, and the program is building public-private and inter-agency collaborations that have great potential for further advances in the future.
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number of applications users felt excluded from EOS data. On the other hand, the reason for EOS is scientific, and science users and uses must be given top priority: Given limited and strained resources, if EOS is operated in part to serve applications users, its primary users and purpose will be compromised. It is possible that the Land Remote Sensing Commercialization Act of 1984 might offer a solution to this potential problem. That is, it is possible that "commercialization" could provide the needed separation between the scientific purposes of EOS and the potentially broader, practical usefulness of its data. An approach worth studying would be to offer one or (better) two "ports" into EOS/DIS to commercial data providers. The exact definition of a "port" would have to be negotiated, but basically NASA through the commercial entities would offer EOS data at cost plus a fee or royalty. Having two competing offerors should keep data prices to users down to reasonable levels. A competitive selection would award the ports to the two bidders proposing the best deal to the government and to applications users. It would be clear that in doing so NASA's purpose would be to make EOS data available cheaply and fairly to existing commercial and other applications users; not to promote or generate an applications community. Such an approach could benefit the EOS program: EOS could concentrate on Earth systems science and leave applications to other relevant organizations.

REFERENCES

Earthquest, Summer 1990, Vol.4, No.2, p. 6.

Keystone Center, Keystone Landsat Policy Dialogue. Keystone, Colorado, October, 1989.

NASA, The Earth Observing System: EOS, A Mission to Planet Earth, EOS Program Office, February, 1990.

NASA, NASA Earth Science and Applications Division: The Program and Plans for FY 1988-1989-1990, September, 1988.

NASA, Linking Remote-Sensing Technology and Global Needs: A Strategic Vision, A Report to NASA by the Applications Working Group, Washington, D.C., 1987.

NASA, NASA Research Announcement Soliciting Proposals for Commercial Applications Research and Development in Earth Observations, NRA 87-OSSA-6, Office of Space Science and Applications, 1987.

NOAA (National Oceanographic and Atmospheric Administration)/NASA, Space-Based Remote Sensing of the Earth from Space: A Report to the Congress. Government Printing Office, Washington, D.C., September, 1987.

Space Applications Board, Remote Sensing of the Earth from Space: A Program in Crisis, National Research Council, National Academy Press, Washington, D.C., 1985.

James V. Taranik. "Landsat, Privatization, Commercialization and the Public Good," Space Commerce, Vol.1, pp.67-80. 1990.

Thomas. J., Leckenby, D., Erickson, L., Thomas, S., Isaacson, L., and Murray, R., "Wildlife Habitat by Design: National Forests in the Blue Mountains of Oregon and Washington," Transactions of the 51st Wildlife and Natural Resources Conference. 1986.

U.S. House of Representatives, Subcommittee on Space Science and Applications of the Committee on Science and Technology, United States Civilian Space Programs: Volume II. Applications Satellites. Prepared for the U.S. House of Representatives by the Science Policy Research Division, Congressional Research Service, Library of Congress Serial-M (Committee Print), Government Printing Office, Washington: May, 1983.

APPENDIX A
INTERVIEW LIST

USERS

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APPENDIX B

Principal Investigator and User Discussion Questions

Principal Investigator Discussion Questions

1. What are the roles of each of the investigators in your project?
2. Which data sets are you using for your research, and how do you access them?
3. What will the final products of your work be?
4. Who will use them?
5. Have you worked with NASA, other federal agencies, or your co-investigators on related projects in the past?
6. What are your follow-on research plans?
7. What are your future data needs? Do you anticipate using Earth Observing System data?
8. What are the major impediments to your research?

User Discussion Questions

1. What is your role in the EOCAP Project?
2. What does your company or agency hope to get from the project?
3. What is your company or agency contributing to the project?
4. How will you gauge the success of this project?
5. What are the impediments to your work on this project? What are the successes?
6. Would you participate in a project like EOCAP again?

APPENDIX C

INSTITUTIONS AND ORGANIZATIONS PARTICIPATING IN EOCAP PROJECTS

UNIVERSITIES

University of California, Berkeley
University of Minnesota
University of Maryland
Purdue University
Oregon State University
Louisiana State University
San Diego State University
University of Maine
University of South Carolina
Ohio State University
Middle Tennessee State University

FEDERAL AGENCIES

US Department of the Interior
 Fish and Wildlife Service
 National Park Service
 Bureau of Land Management
 Geological Survey
US Department of Agriculture
 Forest Service
 Agricultural Statistics Service
Department of Commerce
 National Oceanographic and Atmospheric Administration
 National Environmental Satellite Data and Information
Service
 National Weather Service
 National Marine Fisheries Service
National Aeronautics and Space Administration
 Stennis Space Center
 Ames Research Center

STATE AND LOCAL AGENCIES

California

San Diego Area Governments

Florida

Department of Natural Resources
Marine Research Institute

Indiana

Miami County
Extension Office
Office of the Surveyor
Agriculture Stabilization Conservation Service
Tax assessor
Soil Conservation Service

Louisiana

Geological Service

Minnesota

Department of Natural Resources
Forestry Division

Oregon

Coastal Oregon Productivity Enhancement Organization
Cooperative Wildlife Research Unit
Department of Fish and Wildlife

RESOURCE PRODUCTION COMPANIES

Amoco Production Co.
ARCO Oil and Gas Co.
Lamb Weston (Agriculture)
Mobil Research and Development Corp.
Sierra Pacific Industries (Timber)
Unocal

NON-PROFIT ORGANIZATIONS

Ducks Unlimited
National Geographic Society

SYSTEMS DEVELOPMENT COMPANIES

ERDAS
ESRI (ARCINFO)
User Systems, Inc.

VALUE-ADDED COMPANIES

James W. Sewall Company (Utilities, Land Use, Forestry)
Cropix (Agriculture)
RPI International (Oil Spill Response, Coastal Resources)
Systems West (Marine Transportation, Fisheries)
TGS Technology, Inc.
Weather Management Consultants (Forecasting)
Geoinformation Services, Inc. (Geographic Information Systems)
Vestra Resources
Pacific Meridian
Spectroscan